1,150,306

PATENT SPECIFICATION

DRAWINGS ATTACHED

1,150,306

Date of Application and filing Complete Specification: 25 July, 1966.
No. 33400/66.
Two Applications made in Japan (Nos. 47201 and 47202) on 5 Aug., 1965.
Application made in Japan (No. 15080) on 12 March, 1966.
Application made in Japan (No. 20970) on 5 April, 1966.
Complete Specification Published: 30 April, 1969.

Index at acceptance:—C5 E14
Int. Cl.:—B 01 j 1/12

COMPLETE SPECIFICATION

Improvements in or relating to method and apparatus for Treating Liquid Fuel Oil

We, COAL RESEARCH INSTITUTE, a Japanese Institute, of 1—1—1 Odasakae-machi, Kawasaki-shi, Kanagawa-Ken (Japan) and KAY SEVEN CO., LTD, a Japanese Body Corporate, of 2—2—1 Marunouchi, Chiyoda-ku, Tokyo (Japan) do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a method and apparatus for treating liquid fuel oil.

As the internal and external combustion engines have become widely used in the industrial field, the research has been directed to the improvement of fuel in order to improve the performance of the engines and promote the economy. Recently, it has been proposed to irradiate the liquid fuel oil with ultrasonic waves thereby finely dividing and dispersing the impurities contained therein.

In general, when it is desired to irradiate a liquid with ultrasonic waves, it has been the practice to apply the ultrasonic wave to the liquid which is contained in a treating tank without causing movement of the liquid. In such ultrasonic irradiation there is much trouble in charging and discharging the liquid into and out of the treating tank and, what is more important, it is difficult to apply the ultrasonic wave uniformly throughout the mass of liquid contained in the tank. Thus, although the ultrasonic irradiation of liquid fuel oil has been proposed, it could not be put into practice up to now.

Heavy oil commonly used in an internal combustion engine, particularly in a Diesel engine, is classified according to its quality in two or three grades which are substantially different in cost. An internal combustion engine, particularly a Diesel engine, is usually so designed as to employ the highest grade of heavy oil, but if only the highest grade of heavy oil is employed in a marine engine or the like of low speed and high power type, the cost for the fuel is much increased. Under these circumstances, the lower grade of heavy oil is sometimes employed by improving the method of combustion. However, the lowest grade of heavy oil has high viscosity and contains a high percentage of impurities, so that if the lowest grade is used in a Diesel engine, the combustion efficiency is low and the cylinders of the engine are adversely affected.

According to the present invention there is provided a method for treating liquid fuel oil, comprising the steps of circulating the liquid fuel oil from at least one supply source through at least one circulating line including at least one combustion zone of at least one engine and applying at least one ultrasonic wave to said liquid at at least one point in each circulating line.

The method may also include the step of circulating the heavy oil from at least one supply tank through at least one circulating line including at least one pressurizing zone and at least one heating zone for the heavy oil and nozzle or burner means adjacent to said combustion zone.

The method may also include the step of circulating the liquid fuel oil from said supply source through at least one passage preferably having opposed substantially flat faces to said combustion zone and emitting at least one ultrasonic wave from at least one of the flat faces towards the opposite one to apply the ultrasonic wave to the liquid flowing therethrough.

Preferably, the method includes circulating said liquid fuel oil through restricting plate means provided in said passage preferably between said opposed flat faces and emitting at least one ultrasonic wave alternately from at least one of the flat faces towards the opposed other one to apply the ultrasonic wave to the restricted flow of liquid.

Apparatus for carrying out the methods

referred to above may include at least one supply source of liquid fuel oil, at least one combustion zone of at least one engine, at least one circulating line for circulating the liquid, and ultrasonic wave applying means disposed in each line.

Preferably the apparatus includes nozzle or burner means adjacent to said combustion zone and connected to and fed by said circulating line and pressurizing means and heating means arranged in said line for pressurizing and heating the heavy oil flowing therethrough, said ultrasonic wave applying means being disposed in said line between said supply source and said nozzle or burner means.

Preferably at least one passage is provided in said line, said passage having opposed substantially flat faces for circulating said liquid fuel therethrough and a plurality of vibrators forming said ultrasonic wave applying means, alternately arranged in the flat faces of said passage transversely to the liquid flowing therethrough.

Preferably the apparatus also includes at least two vibrator mounting members cooperating to form at least one liquid passage having substantially flat faces therein and at least one or more vibrators fixed in each of said mounting members transversely to one flat face.

The present invention will now be described in greater detail by way of examples with reference to the accompanying drawings, wherein:—

Figure 1 is a schematic diagram showing a heavy oil feeding system of a marine Diesel engine embodying the present invention;

Figure 2 is an elevation showing the ultrasonic treating apparatus constituting the essential part of the invention, the right hand half being shown in section;

Figure 3 is a side elevation of the same;

Figure 4 is a section along line IV—IV in Figure 2;

Figure 5 is a section along line V—V in Figure 2;

Figure 6 is a longitudinal section showing another embodiment of the ultrasonic treating apparatus according to the invention;

Figure 7 is a plan view of the same;

Figure 8 is a side elevation showing another form of the ultrasonic treating apparatus, the lower half being in section; and

Figure 9 is a front elevation of the same, the lower half being in section.

Referring to the drawings, Figure 1 illustrates an example of a heavy oil feeding system for a marine Diesel engine embodying the present invention. The system shown in Figure 1 comprises a supply tank 1 of heavy oil, a thermometer 2, a booster pump 3, a heater 4, jet pumps 5 having a nozzle 6, a circulating pipe 7 for circulating the heavy oil from the supply tank 1 through the booster pump 3 and heater 4 back to the supply tank 1, feeding pipes 8 for feeding the heavy oil from the pipe 7 to the jet pumps 5, a circulating pipe 9 for circulating the heavy oil, which has been fed to the jet pump 5 but has not been supplied to the nozzle 6, back to the supply tank 1 or the pipe 7. An ultrasonic treating apparatus "A" having vibrators 10 is disposed along the pipe 7 between the heater 4 and the pipe 8. The heavy oil delivered from the supply tank 1 passes through the pipe 7, and is pressurized by the booster pump 3 and heated by the heater 4. Then the heavy oil passes through the ultrasonic treating apparatus "A" where the oil is irradiated with at least one ultrasonic wave, and then a part of the oil passes through the pipe 8 to the jet pump 5, while the other part passes through the pipe 7 and is returned to the supply tank. A part of the heavy oil fed to the jet pump 5 passes to the nozzle 6 from which it is ejected into the engine, while the other part passes through the pipe 9 to the supply tank 1 or to the pipe 7. The heavy oil passing through the pipe 7 is subjected to the effect of the ultrasonic wave at the apparatus "A", which serves to violently stir the heavy oil and disperse the substances contained therein uniformly and at the same time serves to cut off the intermolecular bonds to produce the hydrocarbon of lower molecular weight. Furthermore, the vibration of the ultrasonic wave serves to cause the electric potential at surface to go up by the friction between the molecules of the hydrocarbon, thus producing ionization, while it serves to finely divide the impurities contained therein and to decrease the viscosity of the heavy oil as a whole, whereby the combustion effect is improved. The booster pump 3 and the heater 4 are used as desired to pressurize and heat the heavy oil.

Figures 2 to 5 illustrate one form of the ultrasonic wave treating apparatus "A". Referring to the drawings, the apparatus "A" comprises a pair of mounting members 12 and 12a for mounting the vibrators 10, which cooperate to define a passage, for example of square cross-section, having flat faces 12' and 12'a. Two vibrators 10 are mounted in each of the mounting members and these vibrators are altertately disposed in the mounting members 12 and 12a at a constant distance along the passage so that the ultrasonic waves are alternately directed from one member 12 or 12a to the other 12a or 12. The vibrator 10 consists of a horn 10a formed with a mounting flange 13, which is mounted on the mounting member, and a packing 14 fills up the space between the horn 10a and the mounting member 12, 12a to prevent the liquid fuel from leaking therebetween. The front side of the packing 14 is supported by a plate 15. Vibrator covers 16 and 17 are fixed to the mounting members 12, 12a and cooling fans 18, 19 are attached to said covers. Reflectors 20 are so

disposed on the mounting members 12, 12a that each reflector confronts the forward end of the horn of each vibrator 10 and reflects the ultrasonic wave received from the latter. Restricting plates 21 having triangular cross section and fixed on the mounting members 12, 12a serve to restrict the passage formed by the members 12 and 12a at the position where the ultrasonic wave is applied to the liquid passing therethrough and to produce turbulent flow in the liquid which has passed through the restricting plates. The mounting member 12 has a connecting flange 22 at the entrance opening 22a, which is connected with a flange 24 of a valve 23, which has another flange 25 which is connected with the pipe 7. A pipe 26 is connected to the ultrasonic treating apparatus "A", by means of its flange 27 fixed to the member 12a and is adapted to feed the treated fuel oil from an outlet 26a of the member 12a to a next ultrasonic treating apparatus or the pipe 7. Terminals 28, 29 are attached to the covers 16, 17. In the form as described above, the passage formed between the mounting members has a rectangular shape in cross section, but it may be of curved shape provided that the confronting flat faces 12' and 12'a must be formed. In the drawings, the restricting plates 21 are disposed at both sides of the passage in confronting relationship in order to uniformly irradiate the fuel oil with ultrasonic waves, but these restricting plates may be arranged at both sides of the passage in an offset relationship so as to form a zigzag path therebetween.

The present invention takes advantage of the properties of ultrasonic waves, that is a stirring and dispersing action and a cutting action. When the liquid fuel oil such as heavy oil, gasoline, kerosene, light oil or the like is subjected to the action of an ultrasonic wave having a suitable power and frequency, the liquid is stirred and the components contained therein are uniformly dispersed. Furthermore the bond between the molecules of the component having relatively high molecular weight is cut off to produced hydrocarbon of lower molecular weight, and the hydrocarbon causes the rise of electric potential at surface by the friction between the molecules owing to the ultrasonic vibration, that is, produces ionization, while the impurities contained in the fuel oil are stirred and divided into fine particles and decrease the viscosity of the oil as a whole, thereby improving the combustion effect, decreasing the amount of consumption and minimizing the adverse effects of the impurities on the engine. Where methanol, water, a supporter of combustion or the like is added to the oil, this additive is uniformly dispersed in the fuel by the action of the ultrasonic wave to produce a kind of emulsion, thus improving the combustion effect. In the present invention, the liquid fuel oil is effectively and uniformly irradiated with an ultrasonic wave while passing through the circulating line at a suitable point between the supply tank and the burning zone of the engine, whereby the combustion effect is much improved, the amount of consumption is decreased and the adverse effects of the impurities are considerably decreased, resulting in the economy of cost for fuel and decreasing the trouble required for maintenance, repair and exchange of parts of an engine. In accordance with the present invention, the heavy oil of lowest grade can be improved to obtain the combustion effect which is similar or superior to that of the highest grade heavy oil. The test made by the inventors shows that when the heavy oil of lowest grade having a specific gravity of 0.950 (15,5°C), a viscosity at 50°C of about 574 sec. and including impurities of 150—258 μ, is irradiated with an ultrasonic wave of 300 VA and 27 kHz by the apparatus as described above at a flow rate of 600—1200 ml/min., the impurities are divided into fine particles of 10—20 μ.

The ultrasonic treating apparatus according to the present invention is adapted to pass the liquid fuel oil through the path formed with confronting flat faces and to apply the ultrasonic wave to said flowing liquid alternately from the flat face of one side to the flat face of the other side, thus effectively and uniformly irradiating the liquid with an ultrasonic wave, and where the restricting plates are provided, the liquid is propelled through the passage while creating violent turbulent flow, thus increasing the action of the ultrasonic effect. When the passage is formed by connecting two vibrator mounting members, the passage can be easily and safely repaired and serviced by separating the two members.

Figures 6 to 9 illustrate other embodiments of the ultrasonic treating apparatus according to the present invention. Referring to Figures 6 and 7, the vibrator mounting member 31 has a passage 32 therein and a vibrator supporting opening 33, into which a horn 36 of a vibrator 35 is inserted so as to project into said passage 32 at the forward end and is fixed thereto by applying its flange 37 against a flange 34 of said mounting member and fastening a fixing plate 38 which is bolted thereto. The member 31 has a projecting wall 39 at one side and a recessed wall 40 at the other side, which are adapted to cooperate with each other when a plurality of members are connected together. The passage 32 is so formed that the liquid flowing therethrough is restricted at the zone where it is subjected to the ultrasonic wave and its sectional shape may be circular or rectangular. Connectors 41 and 42 for connecting with the conveying pipes have passages 43 and 44 connecting with the passage 32 and the passage of the conveying pipes, flanges 45 and 46 connected to the vibrator mounting members, flanges 47

and 48 adapted to connect with the conveying pipes and walls 49 and 50. The flange 45 is formed with a recess 51 for fitting with the projecting wall 39 and the flange 46 is formed with a projecting wall 52 for fitting with the recess 40. The flanges 47 and 48 have projecting walls 53 and 54 engaging the flanges of the conveying pipes. The flange 45, the vibrator mounting member 31 and the flange 46 are fastened together by a bolt 56 and a nut 57, with packings 55 being interposed between the parts. When two members 31 are connected, these are arranged at 180° with respect to each other, as shown in Figure 6 and when more than two members are connected, they are arranged at 180° alternately.

Assuming that the liquid flows from left to right in Figures 6 and 7, the liquid fuel oil fed to the passage 32 through the passage 43 is restricted at the end of the horn 36 where it is subjected to the action of the ultrasonic wave, and then the liquid is expanded to produce turbulent flow therein. The liquid is again restricted where it is subjected to the action of the ultrasonic wave and then expanded again to further produce turbulent flow and it passes to the conveying pipe.

Figures 8 and 9 illustrate another embodiment. In this form, a vibrator mounting member 61 has a passage 62, in which a plate 64 having four small holes 63 is provided. Vibrator mounting holes 65 are formed in the member 61 at right angles to the passage 62 and vibrators 67 having horns 68 are inserted in the holes so as to project into the passage and fixed by fastening plates 70 which clamp flanges 69 provided on the horns 68 to flanges 66 of the member 61 by means of bolts. The member 61 has a projecting wall 71 at one side and a recess 72 at the other side, by means of which the member 61 can be connected to another mounting member or the conveying pipe. The liquid fed by one of the conveying pipes is restricted at the plate 64 and divided into four streams, where it is subjected to the action of the ultrasonic wave from the horns. Then the liquid passes to the other conveying pipe.

In the forms shown in Figures 6 to 9, the mounting member may be constructed as a short integral part, to which one or more vibrators can be mounted, so that the desired number of mounting members may be connected together according to the kind and quality of the liquid to be treated. Furthermore these constructions can be easily and economically manufactured.

We have made tests on an experimental ship equipped with the apparatus according to the present invention in the case where the intermediate grade of heavy oil is used without irradiation by an ultrasonic wave and in the case where the lowest grade of heavy oil is used with irradiation by an ultrasonic wave. The result is shown in the following Table I.

TABLE I

	Intermediate grade of heavy oil without ultrasonic wave	Lowest grade of heavy oil with ultrasonic wave	Comparison
Test Period	1964.10.7 — 1965.4.5	1965.10.7 — 1966.3.30	
Running Distance	23384.7 sea miles	19881.6 sea miles	
Running Time	1952h 45mn	1616h 45mn	
Running Time	81.36 days	67.37 days	
Steaming Time	1918h 24mn	1586h 18 mn	
Steaming Time	79.93 days	66.10 days	
Average Speed	12.19 kt	12.53 kt	0.34 kt increase
Average Draught	4.46m	4.59m	0.13m increase
Consumption Fuel	B Heavy Oil A Heavy Oil 724.694 kl 3.274 kl	C Heavy Oil A Heavy Oil 565.669 kl 11.655 kl	
	Total 727.968 kl	Total 577.324 kl	
Fuel Consumption Rate	8947.5 l/day	8569.4 l/day	378.1 l(4.23%) decrease
	8179.2 kg/day	8122.6 kg/day	56 6kg(0.69%) „
	31.130 l/sea mile	29.030 l/sea mile	2.092 l(6.72%) „
	28.500 kg/sea mile	27.524 kg/sea mile	0.976kg(3.42%) „
Fuel Index*	(l/day) 53.976	62 191 l/day	17.7% Good
	(kg/day) 59.050	65.606 kg/day	11.1% Good

* Fuel Index $K = v^3.\Delta^{2/3}/C$. v = speed knot/hr. C = F.O. consumption. Δ = displacement.

WHAT WE CLAIM IS:—

1. A method for treating liquid fuel oil, comprising the steps of circulating the liquid fuel oil from at least one supply source through at least one circulating line including at least one combustion zone of at least one engine and applying at least one ultrasonic wave to said liquid at at least one point in each circulating line.

2. The method according to claim 1, wherein it includes circulating the heavy oil from at least one supply tank through at least one circulating line including at least one pressurizing zone and at least one heating zone for the heavy oil and nozzle or burner means adjacent to said combustion zone.

3. The method according to claim 1 or 2, wherein it includes circulating the liquid fuel oil from said supply source through at least one passage preferably having opposed substantially flat faces to said combustion zone and emitting at least one ultrasonic wave from at least one of the flat faces towards the opposite one to apply the ultrasonic wave to the liquid flowing therethrough.

4. The method according to claim 3, wherein it includes circulating said liquid fuel oil through restricting plate means provided in said passage preferably between said opposed flat faces and emitting at least one ultrasonic wave alternately from at least one of the flat faces towards the opposed other one to apply the ultrasonic wave to the restricted flow of the liquid.

5. An apparatus for carrying out the method according to any one of claims 1 to 4, including at least one supply source of liquid fuel oil, at least one combustion zone of at least one engine, at least one circulating line for circulating the liquid, and ultrasonic wave applying means disposed in each line.

6. Apparatus according to claim 5 for treating heavy oil, wherein it includes nozzle or burner means adjacent to said combustion zone

and connected to and fed by said circulating line and pressurizing means and heating means arranged in said line for pressurizing and heating the heavy oil flowing therethrough, said ultrasonic wave applying means being disposed in said line between said supply source and said nozzle or burner means.

7. Apparatus according to claim 5 or 6, wherein at least one passage is provided in said line, said passage having opposed substantially flat faces for circulating said liquid fuel therethrough and a plurality of vibrators forming said ultrasonic wave applying means, alternately arranged in the flat faces of said passage transversely to the liquid flowing therethrough.

8. Apparatus according to claim 7, characterized in that it further includes restricting plate means in said passage.

9. Apparatus according to claim 5 or 6, characterized in that it includes at least two vibrator mounting members cooperating to form at least one liquid passage having substantially flat faces therein and at least one or more vibrators fixed in each of said mounting members transversely to one flat face.

10. Apparatus according to claim 9, characterized in that it includes restricting plate means disposed in said passage.

11. Apparatus according to claim 5 or 6, comprising at least one liquid passage, vibrator mounting member means and vibrators fixed on said vibrator mounting member means transversely to the passage so as to project into said passage, said vibrator mounting member means being connected at the inlet and outlet sides to liquid conveying pipes directly or through connecting members.

12. Apparatus according to claim 11, characterized in that it includes restricting plate means disposed in said passage.

13. Apparatus according to claim 11 or 12, characterized in that it includes a plurality of mounting members connected together in series.

14. The method for treating liquid fuel oil substantially as herein described with reference to the accompanying drawings.

15. Apparatus for treating liquid fuel oil substantially as herein described with reference to and as illustrated in the accompanying drawings.

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Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1969.
Published by the Patent Office, 25 Southampton Buildings, London, W.C.2, from which copies may be obtained.

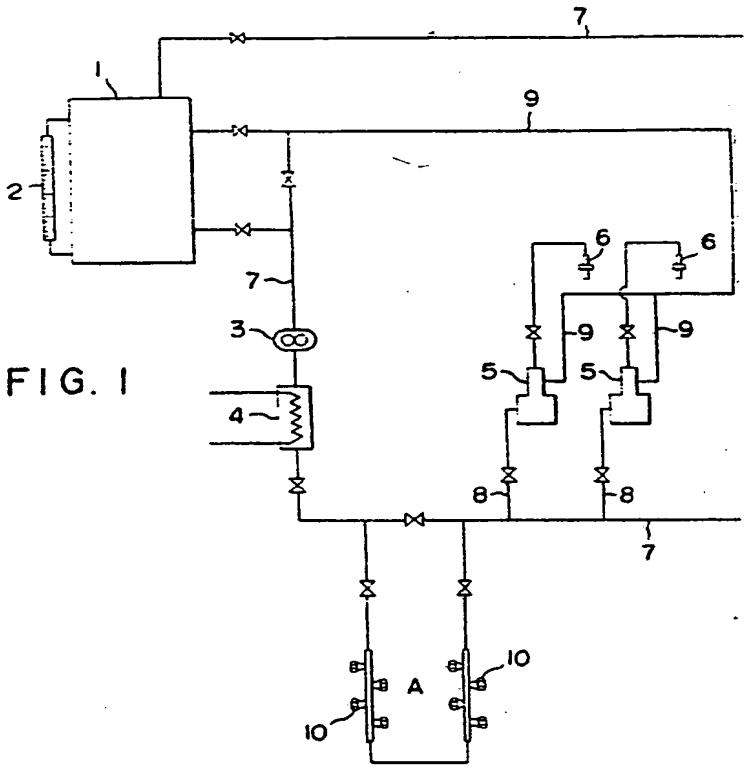
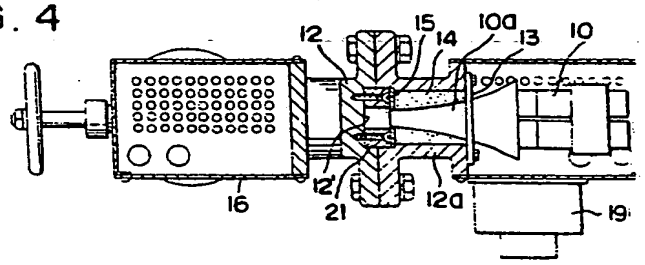


FIG. 1

FIG. 4



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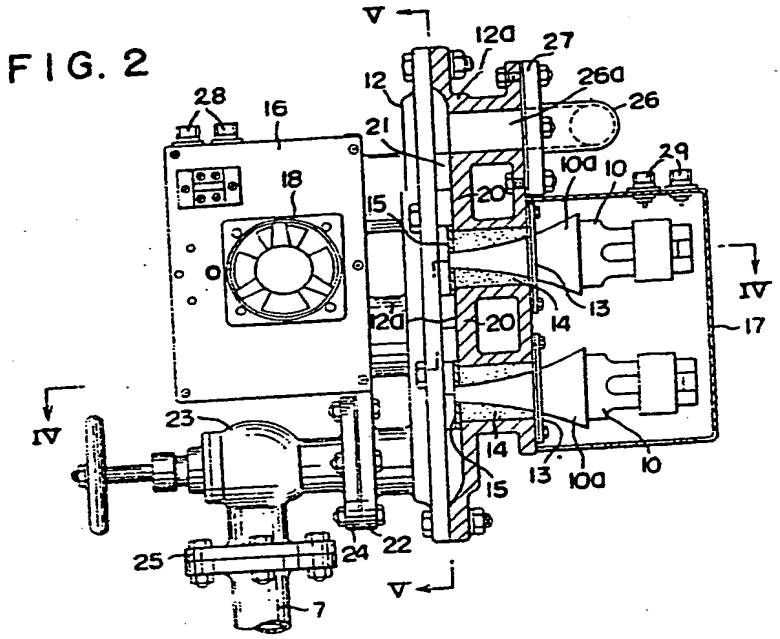
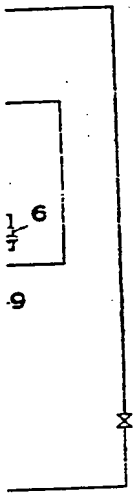
Sheets 1 & 2

FIG. 2





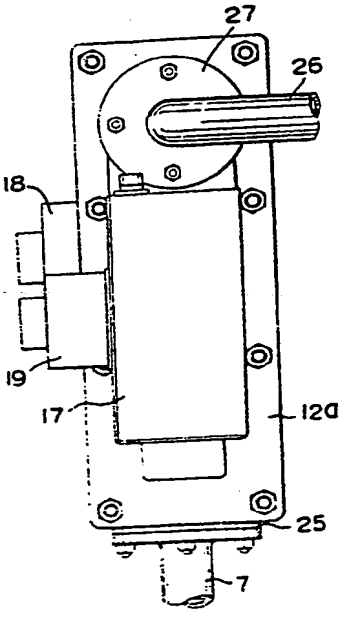
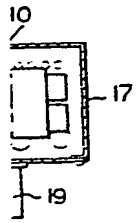


FIG. 3



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Sheets 1 & 2

FIG. 1

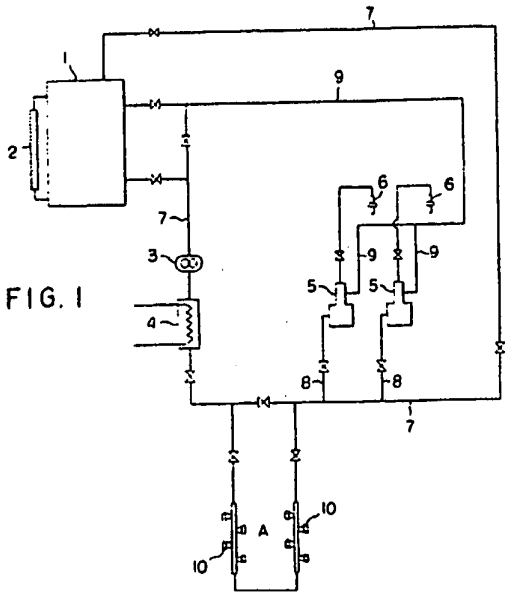

FIG. 2

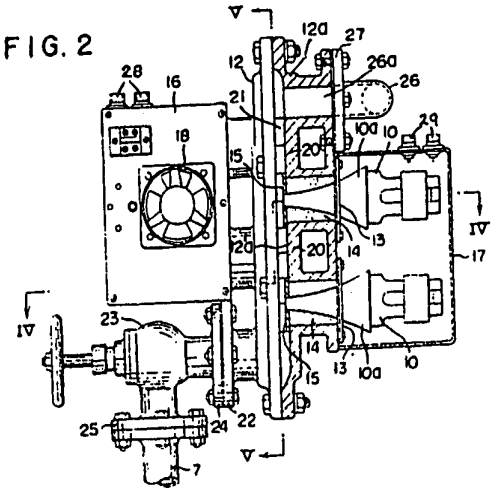

FIG. 3

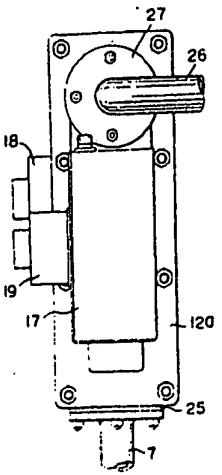

FIG. 4

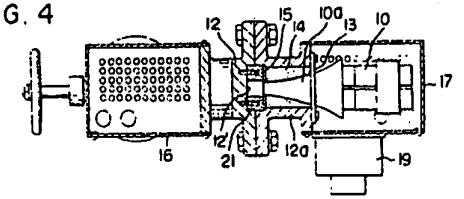

FIG. 5

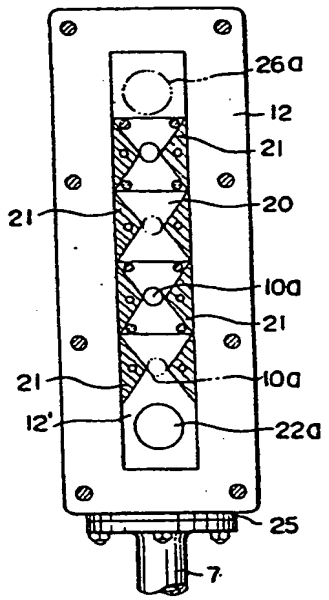

FIG. 6

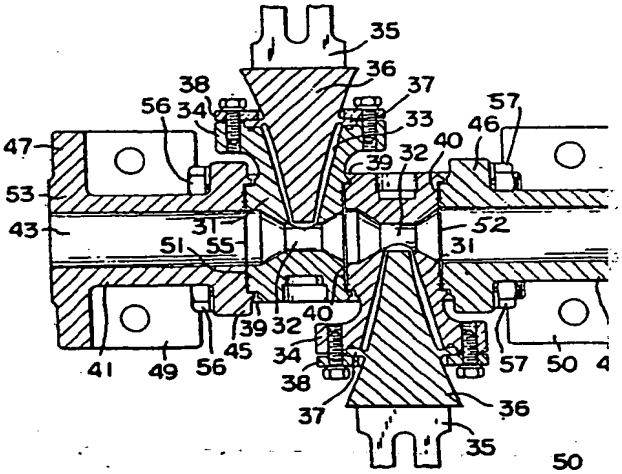

FIG. 7

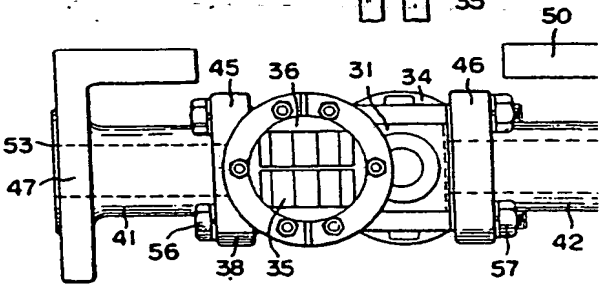

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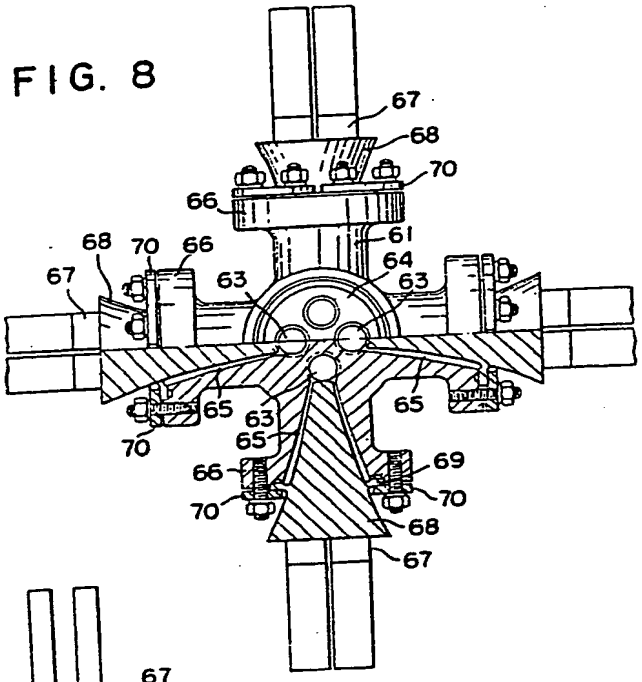
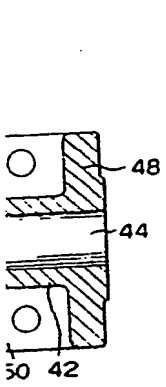
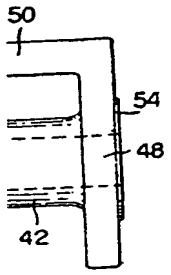
FIG. 8







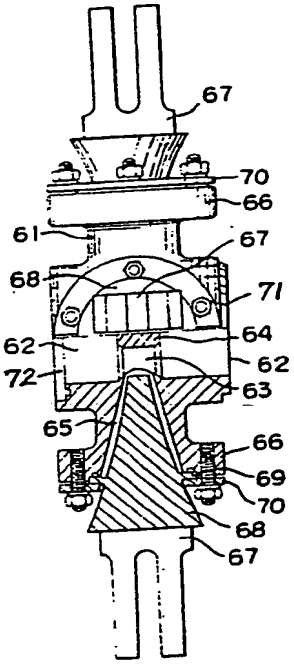


FIG. 9